MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLVIII. JUNE 8, 1888. No. 8

W. H. M. CHRISTIE, M.A., F.R.S., President, in the Chair.

The following candidates were proposed as Fellows of the Society, the name of the proposer from personal knowledge being appended:—

John Harvey Jones, Fairview Villa, Coburg Road, Montpelier, Bristol (proposed by W. F. Denning);

William Henry Maw, Civil Engineer, 18 Addison Road, Kensington, W. (proposed by Sir H. Grubb); and

Albert Taylor, Observatory, Hurstside, West Molesey, Surrey (proposed by J. Norman Lockyer).

Photographic Committee.

At a meeting of the above Committee, appointed by the Council of the Royal Astronomical Society, the following resolutions were passed unanimously:—

1. That this Committee is of opinion that it is undesirable to reopen any fundamental questions settled by the Astrophotographic Congress, and therefore considers that it is not desirable to extend the limits of magnitude for the stars of the photographic chart of the heavens beyond that already defined by that Congress.

2. That this Committee expresses its strong disapproval of the scheme for an International Bureau for measuring the stellar photographs, as proposed in the *Bulletin du Comité International Permanent.*

The Library.

In accordance with a resolution of the Council, the Library of the Society will in future be closed on the FIRST and THIRD Saturdays in each month at 2 P.M.

The Central Office for Astronomical Telegrams. By Professor A. Krueger.

(*Extract from a letter to the President.*)

I have been often surprised that the Central Office for Astronomical Telegrams has only one subscriber in England, while in France we have 5, in Spain and Portugal 3, in Italy 5, in Germany 12, in Austria 4, in Switzerland 3, in Russia 12, in Scandinavia 4, and in Holland and Belgium 4.

Perhaps you would bring the matter before a meeting of the R.A.S. The yearly contribution for those who do not desire telegrams of discoveries of minor planets is at present 2*l.*, or including minor planets, 3*l.*

As the number of subscribers increases, the yearly subscription will be reduced, by reason of the necessary expenses of management being divided among a greater number.

New Arrangement of Electrical Control for Driving Clocks of Equatorials. By Sir Howard Grubb, F.R.S.

In a paper read before this Society last spring I mentioned that it appeared to me likely that the best system for obtaining accurate clock-driving, and that most suitable for photographic work, would be found to be a combination of Dr. Gill's as applied to Lord Crawford's 15-inch equatorial, and mine as applied to Mr. Roberts's equatorial.

I have since worked this out, and the driving apparatus I exhibit to-night (which is intended for the stellar photographic instrument of the Mexican, Chapultepec, Observatory) is the result.

There is nothing novel to remark on in the clock itself except the governor.

In Dr. Gill's control, as applied to the Earl of Crawford's telescope, and in my earliest form, the correction was applied to the governor by an increase or decrease of friction, and it was therefore desirable to keep down the *vis inertiæ* of the governor, but as, in this form, the correction is applied in a totally different manner, it is permissible to employ a very heavy, quick-moving governor, with a corresponding increase of *vis inertiæ*, and this has, as can easily be understood, great advantages in many ways, more particularly in the obtaining of great smoothness of motion.

In this particular governor, instead of balls I use a brass ring loaded with lead, and cut into eight segments; and in addition to gravity, springs are applied, one to each segment, tending to supplement the force of gravity; by which arrangement the speed of the governor is increased from 90 to 135 revolutions,

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Fig. 1.

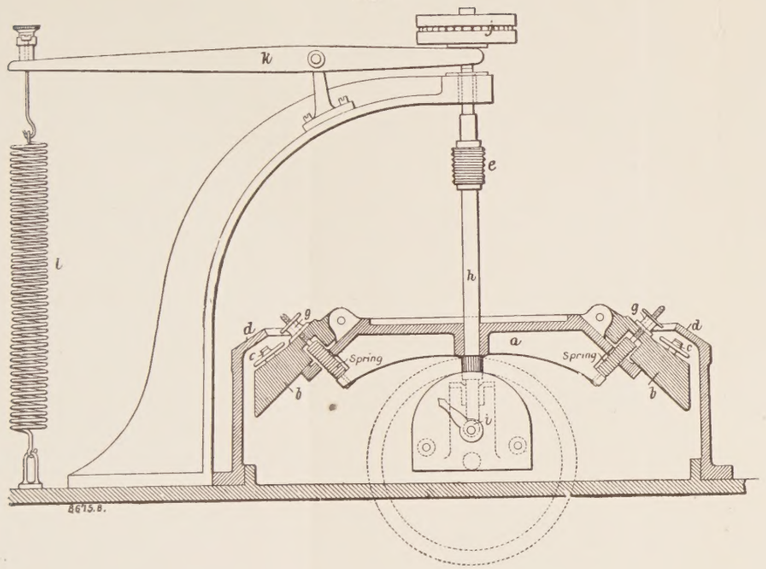


Fig. 2.

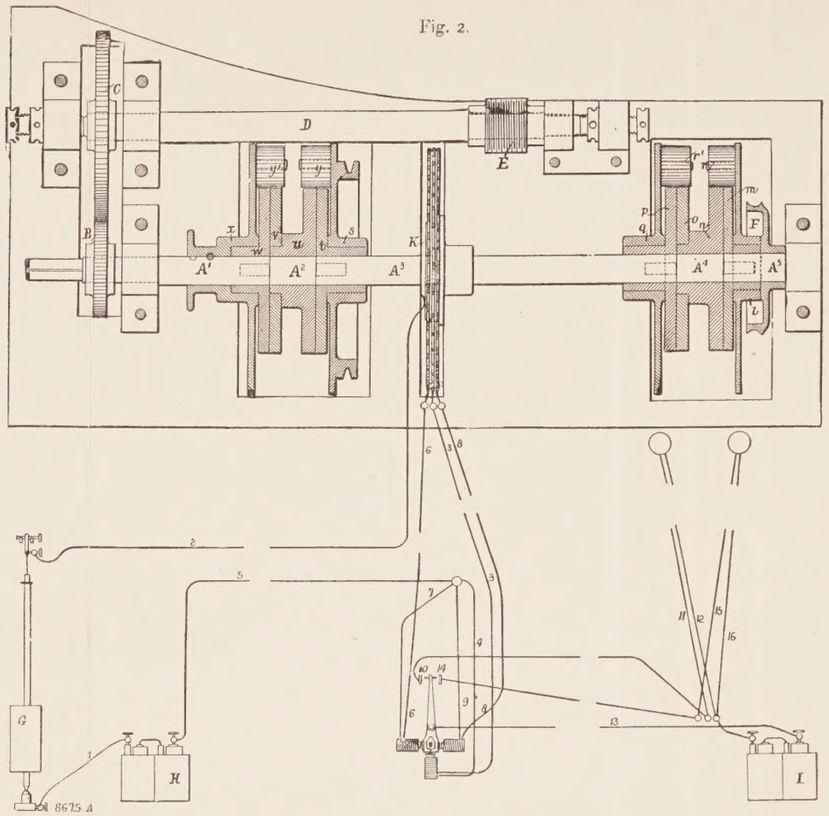


Fig. 3.

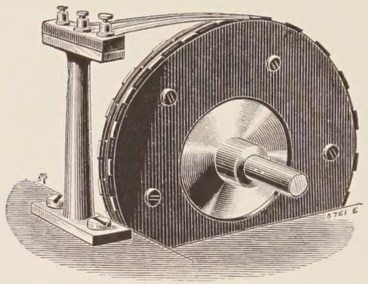


Fig. 4.

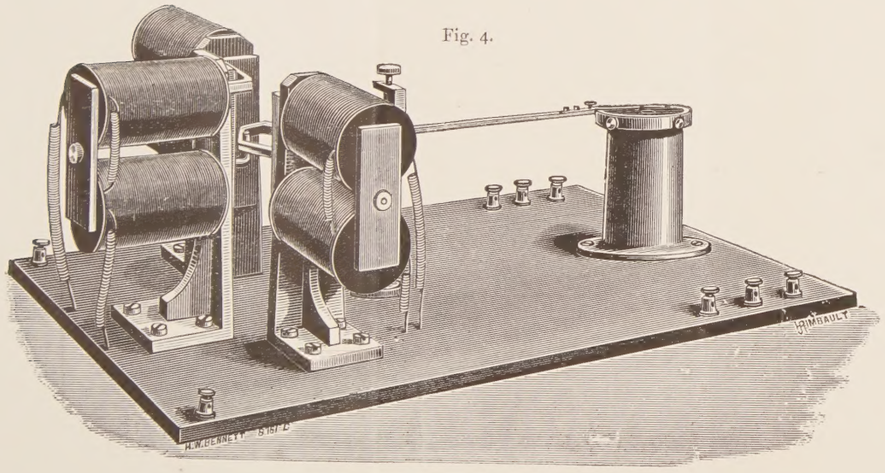


Fig. 5.

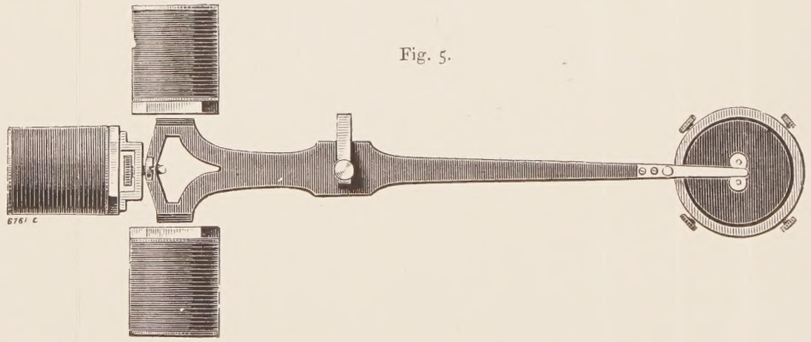


Fig. 6.

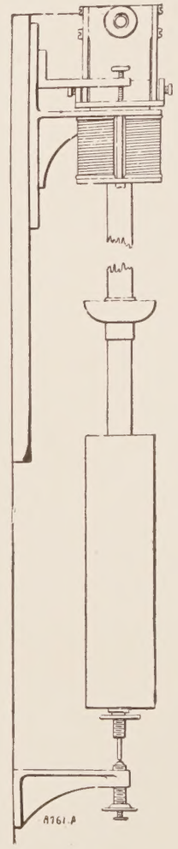
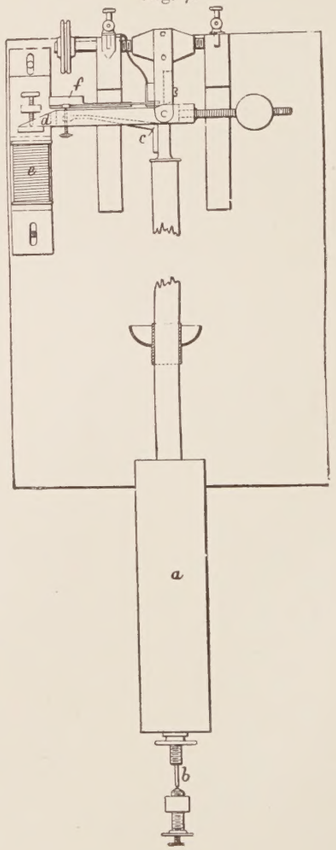


Fig. 7.



and the *vis inertiæ* is represented by some 10,000 foot-pounds per minute.

As the great weight of this governor would cause a considerable amount of friction in the toe bearings, a pair of hardened steel discs, between which a set of bicycle balls roll, are introduced at upper end of spindle. See fig. 1, Plate 2.

Again, to reduce the number of wheels, and consequent errors between the governor and the screw spindle, the governor spindle is furnished with a screw, *e*, on upper end, which gears directly into a wheel, *f*, fig. 2, on counter spindle of screw shaft.

This is a suggestion of Dr. Gill's.

The system of control may be conveniently divided into two distinct parts: first, the *detector*; and, second, the *corrector*; and this second part, the *corrector*, is again divided into the *accelerator* and the *retarder*.

The detector is seen at K, fig. 2, and also in perspective in fig. 3. It consists of three discs of brass, separated by discs of ebonite on which three metallic wipers rub, the brass discs being so cut on edge that the central one presents a set of twenty sharp contact teeth, and each of the others twenty contact spaces separated by spaces of no contact.

The three discs, which revolve together in twenty seconds, are so arranged that no two contacts take place at the same time.

Any current sent through this wheel and contacts will be sent into one or other of the three wipers, whichever is in contact at the exact moment the current passes.

From these three wipers the current is sent into one or other of the three electro-magnets of the relay (figs. 4 and 5), which may be placed at any distance.

If the current passes at the moment the centre disc with its short sharp contact is under its wiper, it is directed into the central electro-magnet of the relay (figs. 4 and 5), which tends to keep the lever central, and in contact with neither of the platinum contacts at the other end.

If the current passes at any other moment, it is directed into one or other of the side electro-magnets, and the lever of relay is driven to one side or another, and makes contact, which brings into play the accelerator or retarder of the correcting apparatus.

The correctors consist of two pairs of differential wheels, of the ordinary type of those used in my equatorials for slow motion in R.A.

The counter-shaft is discontinuous, being cut across between each pair of differential wheels. On the adjacent ends of this discontinuous shaft toothed wheels, *n m*, fig. 2, are attached, cut with a difference of one tooth in forty. Across both wheels gears a pinion, *r* or *r'*, carried on a stud on a plate or disc, itself free to move round the shaft.

In the normal condition of working, the whole of the arrangement revolves together, acting as a clutch, but if the disc carrying the pinion be stopped the motion is transmitted

from the wheel *m* to *n through the pinion*, and a difference of rate + or − occurs according as the driver or the driven wheel has the greater number of teeth. The periphery of the disc is cut into fine teeth, and the armature of an electro-magnet suitably placed is provided with a comb, which engages in these fine teeth and stops the disc whenever that particular electro-magnet has the current directed into it by the relay above described.

The action of this apparatus is as follows: A pendulum beating seconds, shown diagrammatically at G, fig. 2, and more in detail in figs. 6 and 7, closes a circuit once every second, and allows a current from the battery H to flow through the wires 1 and 2 to the central contact ring of the detector. If the telescope is being driven properly this closing of the circuit by the pendulum will be synchronous with the passage of one of the central series of peripheral contact pieces under the contact spring connected to the wire 3, and the current will thus follow the circuit 1, 2, 3, 4, and 5, bringing into action the central electro-magnet of the relay. Referring to figs. 4 and 5, it will be seen that this relay has a vibrating lever, which, when acted upon by the armature of the central electro-magnet, is held in the central position, the effect of its being so held being that no current is transmitted by the relay, and the driving of the telescope is not interfered with. Let us suppose, however, that at the instant the pendulum closes its circuit the telescope is slightly ahead of its proper position. In this case, instead of one of the central series of contact pieces being under the contact spring when the circuit is closed, one of the right-hand series will be under *its* spring, and the circuit will follow the wires 1, 2, 8, 9, 5, bringing into operation the right-hand electro-magnet of the relay, and drawing the lever of the latter over to one side. The effect of this movement of the lever is to close a connection at 10, and cause a current from the battery I to traverse the circuit 13, 10, 11, 12, and bring into action the magnets actuating the clamp which will hold the disc *q* of the retarder, thus retarding the motion of the telescope. On the other hand, if the telescope falls behind its proper rate, the current transmitted by the pendulum will traverse the circuit 1, 2, 6, 7, 5, the lever of the relay will be drawn over to close the circuit at 14, and the current from the relay battery I will traverse the circuit 13, 14, 15, 16, and bring into action the clamp operating the accelerating disc *l*.

The shaft A makes one revolution in 20 seconds, so that during each revolution twenty correcting currents are transmitted by the controlling pendulum. The proportions of the accelerator and retarder are also such that the alteration made in the driving of the telescope equals $\frac{1}{40}$th of the time during which the accelerator or retarder is put into operation. Thus, if the driving of the telescope from any cause becomes $\frac{1}{20}$th of a second in arrear, the controlling apparatus will correct the error

by bringing the accelerator into action for a period of 2 seconds, and so on.

The seconds pendulum by which the control is exerted is shown in detail by figs. 6 and 7. It may be a mercurial or any other type of compensated pendulum, and its bob *a* carries a fine point *b* which at each oscillation closes an electric circuit by passing through a globule of mercury, and so transmits the current to the detector gear already described. The mode of driving the pendulum is as follows: The upper part of the pendulum rod carries a light arm *c*, which as the pendulum oscillates from right to left picks up the weight *f*, shown in fig. 7 as resting on the supporting lever *d*. If the latter remained in the position there shown the arm *c* would simply redeposit the weight at the same level during the reverse oscillation of the pendulum and the latter would receive no impulse. But just before the weight can be thus redeposited the closing of the electric circuit by the pendulum brings into action the electro-magnet *e*, which, attracting the armature, draws down the lever *d*. On the current ceasing and the armature being released, the lever *d* is restored by its counterweight to the position shown in fig. 7, of course relieving the arm *c* of the load *f*. The effect of this is that the weight *f* remains resting on the arm *c* for a longer arc while descending than while ascending, and hence the pendulum receives the necessary impulse.

Slow Motion in R.A.—Besides the ordinary slow motion in R.A. it is purposed to provide a very delicate slow motion, specially suited for correcting, for refraction, &c.

This is accomplished by another set of correctors similar to those above described, and acted on by another pair of electro-magnets (shown at the other end of the counter-shaft in fig. 2).

These electro-magnets are excited from a commutator held in the hand of the observer while watching a star in the guiding telescope.

If he finds a correction necessary, a pressure on one key of the commutator produces a temporary acceleration of $\frac{1}{40}$th part, and a pressure on the other a retardation to the same amount.

This arrangement acts absolutely without any backlash or jerk to instrument.

Note.—It is necessary to employ a second set of correctors for this, for if the same set as that actuated by the automatic control were used, the detector would treat the hand correction as an error and proceed to undo it again.

It is well to mention, in case it may appear that the arrangement shown in fig. 2 is complicated, that in the normal state of things the counter-shaft, with all its correctors, detectors, &c., revolves as one solid piece, and it is only when any correction has to be made that any of this work comes into action.

Slow Motion in Declination.—Every telescope-worker knows how impossible it is to get a declination slow motion absolutely free from "loss," unless by the so-called German form, in which

a screw acts against a long pliable spring, to which there are serious objections. In the arrangement shown in figs. 8 and 9 the advantage of having all backlash taken up by a spring is retained, while a very stiff spring can be employed. In figs. 8 and 9, *a* is

Fig. 8.

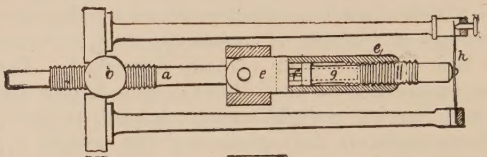
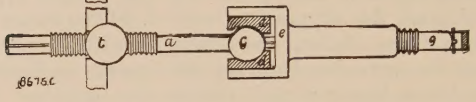


Fig. 9.



the screw by which the adjustment is made, this screw working through a nut *b*, and having a spherical end *c* bearing in the crosshead *d*. Thus, as the screw is turned the distance between the nut *b* and crosshead *d* is varied. At *h* is a short stiff spring, which by means of the screw *g* and sleeve *e* exerts a pressure on the crosshead *d*. At *f* is a square prolongation of the screw *a*, which enters a correspondingly squared hole in the screw *g* so that the latter turns with *a*. But whereas the screw *a* has a right-hand thread, that of the screw *g* is left-handed, so that every increase of distance between the nut *b* and crosshead *d* is accompanied by an equal decrease in the length of the combination *g e*, and thus the pressure exerted by the spring remains constant, whatever may be the position of the crosshead *d*.

Description of a New Observatory for a 3-foot Reflector.
By Edward Crossley.

On the removal of Mr. Common's 3-foot reflector from Ealing the ingenious wooden house, or observatory, designed by Mr. Common was also re-erected at Halifax. The situation at Halifax being much more exposed than that at Ealing, it was soon found very desirable to put up a dome so as more effectively to protect both the instrument and the observer. The present dome was completed in 1887. It is constructed in a similar manner to the excellent dome by Messrs. Cooke of York, at the Greenwich Observatory, except so far as the covering and the shutters and some of the minor details are concerned.

The accompanying plan and section, with the following explanation, will perhaps make the construction plain.

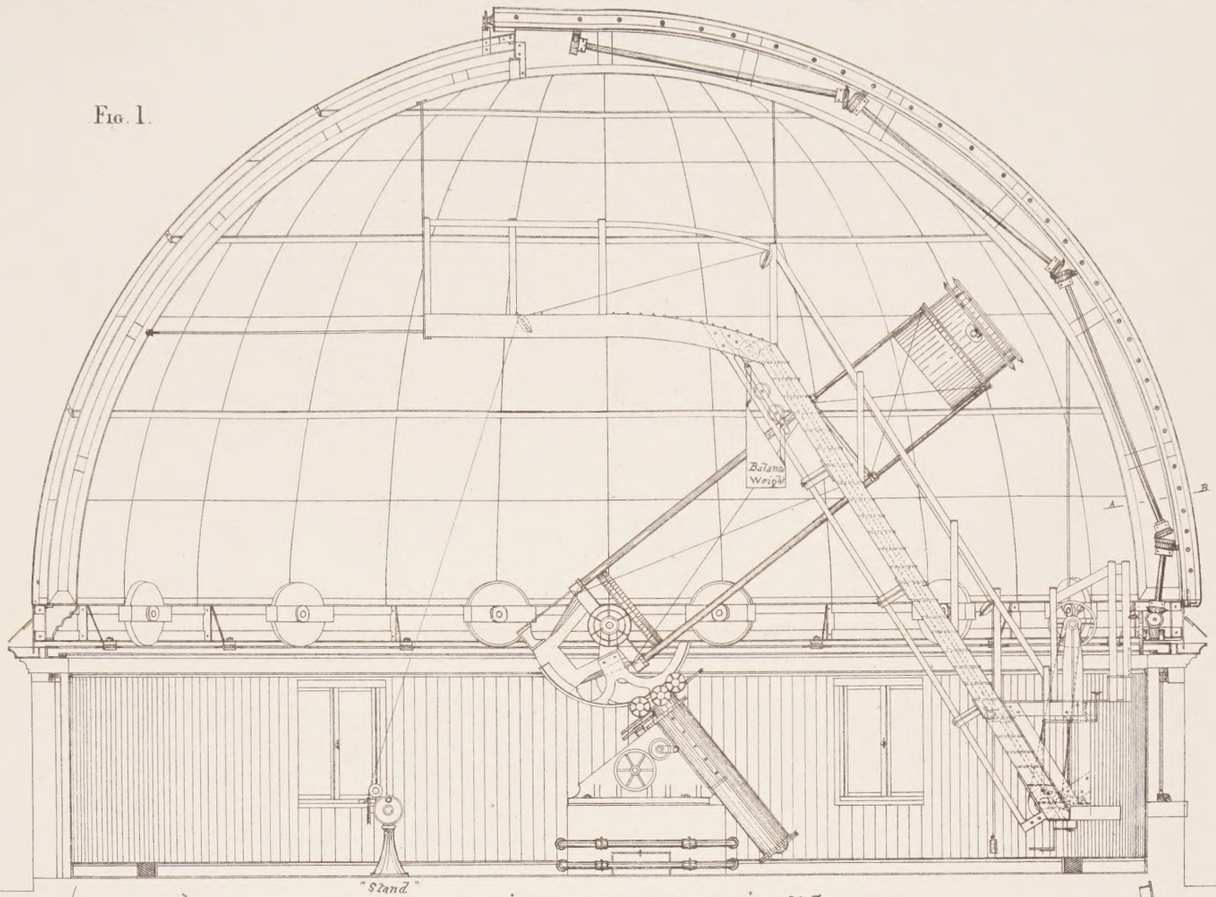
The building is circular, the same diameter as the dome—38 ft. 9 in. outside and 36 ft. 3 in. inside. The walls are stone outside and brick inside. The circular wall is 1 ft. 3 in. thick, 7 ft. 4 in. high above the floor, and finishing with an ashlar

OBSERVATORY FOR 3 Ft. REFLECTOR.

EDWARD CROSSLEY.

BERMERSIDE, HALIFAX, 1887.

Fig. 1.



SECTIONAL ELEVATION ON LINE N.S

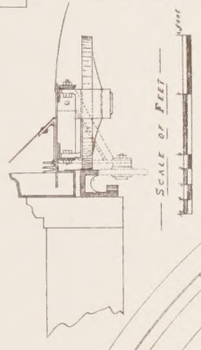


Fig. 2.

SCALE OF FEET

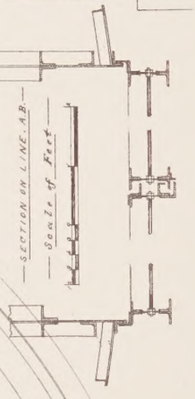
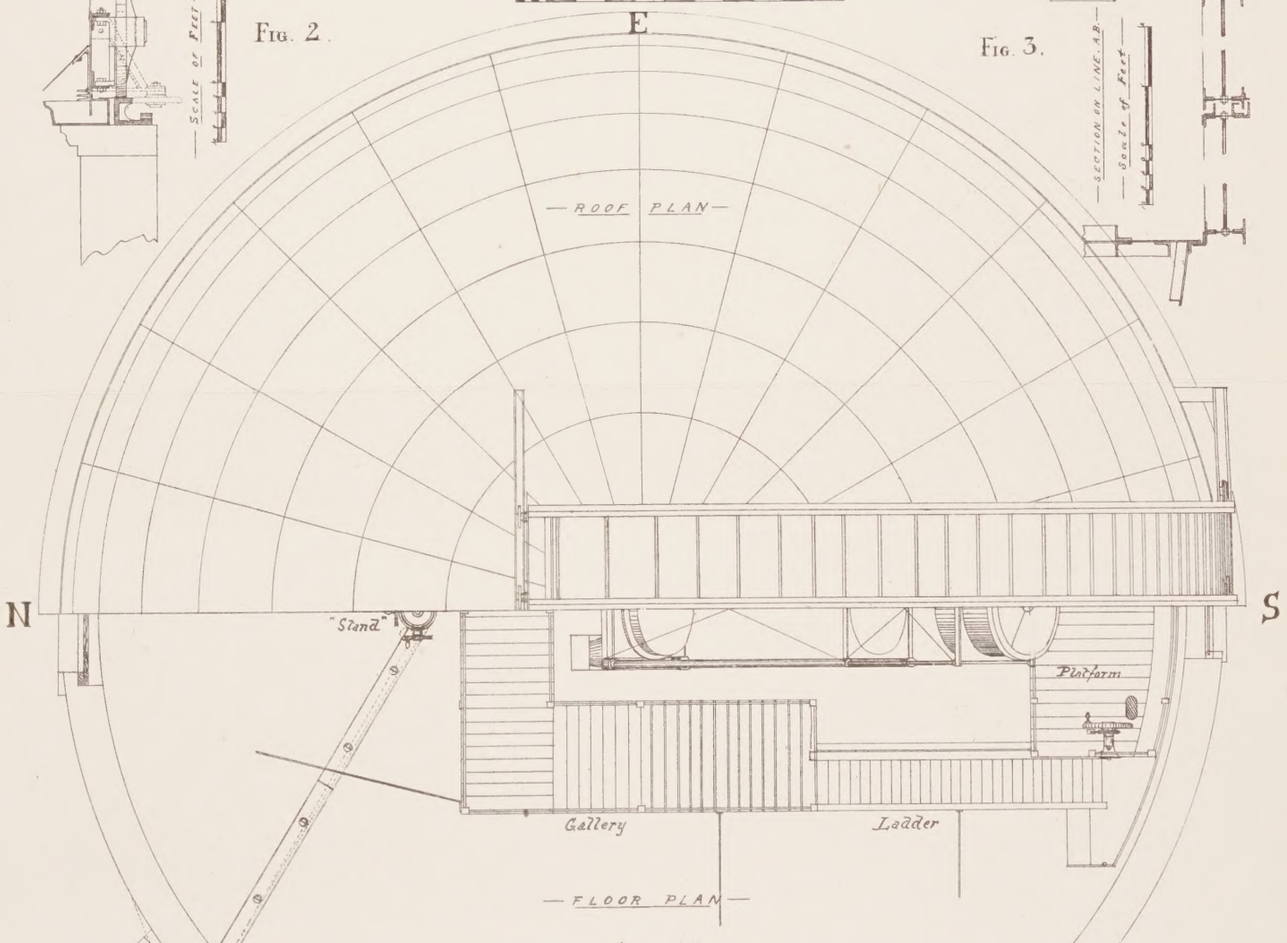


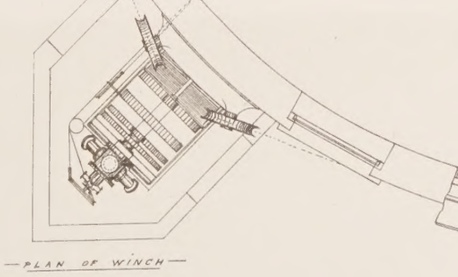
Fig. 3.



ROOF PLAN

FLOOR PLAN

Fig. 4.



PLAN OF WINCH

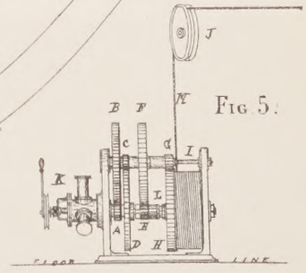


Fig. 5.

SIDE ELEVATION OF WINCH

course carefully levelled to receive the rail. A north doorway and five windows give access and ventilation. A small room at the N.W. corner, with a flat roof, contains an hydraulic winch for moving the dome.

Fig. 2 shows the top of the wall in section on a larger scale.

The rail is of cast-iron, in 24 segments, planed top and bottom, bolted together and to the masonwork, and carrying a toothed rack all round on the inner side containing 1,392 teeth. Outside is the rain-trough. The foundation ring of the dome is made of $\frac{1}{4}$-inch boiler-plate 21 inches deep, with 4-inch angle-iron top and bottom. To this ring are attached the cast-iron frames in which the 14 large wheels rotate that carry the dome, and also the intermediate wheels that keep the dome in its place horizontally. Outside the ring is a snow-guard, set off from the dome to allow the rainwater to enter the trough. There is also a series of double forks, one of which is shown in fig. 2. These forks carry the two wire ropes, $\frac{3}{8}$-inch in diameter, by which the dome is moved round, so that they do not touch the dome and catch the rainwater from it. To make the dome weatherproof, there is placed immediately above the trough and between the ring and the rail a flat strip of galvanised iron attached to the ring, and from the rail a similar strip of felt cloth covering the iron plate. Two stout parallel girders 6 feet apart run from one side of the dome to the other to support the shutters, and form the opening of the dome. These girders are made of $\frac{1}{4}$-inch boiler-plate 11 inches deep, with 3-inch angle-iron both sides, top and bottom, up to the north side of the opening. Along the opening the girders are 17 inches deep, as shown in section, fig. 3, and extend beyond the shell of the dome to form the sides of the opening. These girders are attached to the ring of the dome by angle blocks, as shown in fig. 1 to the north. The foundation ring is divided into 24 equal parts. From 23 of these rise 2-inch T-section wrought-iron ribs bound together by three $1\frac{3}{4}$-inch angle-iron rings, as shown in fig. 1. The 206 sheets of galvanised iron $\frac{1}{12}$-inch thick which form the covering of the dome are riveted to the ribs as well as to each other with 11,000 rivets. The two shutters are parallel, and open horizontally, and are carried at each end by pullies on rails.

Each shutter is opened by a system of shafting, as shown in fig. 1. The shafting is carried up the sides of the opening on each girder, and the lengths are connected by bevil-wheels. Four cogwheels on the shafting work into four racks upon the shutter. The two systems of shafting are connected together at the bottom of the opening by a cross-shaft and bevil-wheels. A worm-wheel upon the cross-shaft, with worm and handle, as shown in fig. 1, enable both shutters to be opened and closed simultaneously in one minute each way. The shutters are shown in section, fig. 3, both closed. The sections are broken to save room. A trough is formed by angle-iron in one of the shutter ribs to catch any rain that may drive in. This trough is partly

packed with tarred gaskin to make a tight joint with the other shutter when closed. In addition to the outer shutters a light shutter 9 feet by 6 feet is carried between the girders at the zenith and rolled back to north when not required. This shutter gives additional protection to the delicate parts of the instrument, and also shuts out the zenith when not required. It is omitted in the drawing, to avoid complication. The rods which connect the shutter-girders form steps for reaching the top of the dome (see fig. 4).

To enable the observatory to be worked with ease by one observer, an hydraulic winch is placed outside the main wall at the N.W. corner. Figs. 4 and 5 show this in plan and elevation. The winch is constructed as follows. Upon a cast-iron bed plate at each end are bolted two vertical frames. These frames carry two parallel shafts, one over the other. The upper one is fixed, forming a stay to the frames. The lower one is driven by the 3-cylinder water-engine *K*, with cylinders 3 inches diameter and 5 inches stroke, fig. 5. The gearing is in four couples, *A*—*B*, *C*—*D*, *E*—*F*, *G*—*H*, numbered respectively 23—109, 23—109, 16—77, 16—77. *A* is the only wheel keyed fast to its shaft. *B*, *C* and *F*, *G* are pairs, moving freely round together on the upper shaft. The pinion *E* slides on the lower shaft, and can be coupled either to wheel *D* or to a block, *L*, which is keyed fast to the shaft, or remain idle between the two. When the pinion *E* is coupled to *D* then all four sets of wheels are at work, and $5\frac{1}{2}$ revolutions of the water-engine will turn the dome round once in 24 hours. When the pinion *E* is coupled to the block *L* only *E*—*F*, *G*—*H* are at work; *A*—*B*, *C*—*D* run idle, and 72 revolutions of the engine will turn the dome round once in 5 minutes. It is obvious that any intermediate speed can be obtained. The wire ropes are fastened at each end upon the drum and dome respectively. As one rope winds on to the drum the other winds off. The pulley *J* is out of place in the drawing. The rope *M* should come to the middle of the drum. Pullies are placed at *M* to take up any slack there may be in the ropes, but are not shown, to avoid complication.

The valve of the water-engine is connected by wire cords under the floor with the stand on the north side of the telescope. The coupling lever of the pinion *E* is also connected in the same manner, so that the speed and direction of the rotation of the dome can be controlled from the floor of the observatory.

The arrangements for supporting the observer at the eye-piece of the reflector are as follows. A substantial wooden gallery, shaped like the letter U, with railings inside and out, is suspended from the top of the dome and stayed laterally with iron rods, as shown in figs. 1 and 4. Two stout ladders descend from the south ends of the U-gallery to within 15 inches of the floor of the observatory. The lower ends of the ladders are firmly connected together, and also suspended from the dome.

Each ladder has an outside railing. Between the ladders is placed the movable platform, with a triangular frame at each end, carrying rollers resting upon cast-iron rails on the inner side of each ladder, and supported by two balance weights, one of which is shown in fig. 1. On the under-side of each rail is a rack. A shaft with pinions at each end gearing into the racks is carried by bearings under the platform. This shaft is turned by an endless chain and handle upon the platform, as shown in figs. 1 and 4. A safety-catch fitting into a notched wheel upon the shaft prevents the platform from falling with two or more persons upon it. The catch is raised by the left foot upon the plate, shown in fig. 4 close to the hand-wheel. The mechanism is indicated in fig. 1. The platform is balanced to carry one person, and is easily raised and lowered.

The mechanism for opening the shutters is worked from the platform. Two light cords are carried up from the stand over pulley-blocks on the west side of the gallery and platform, so that the observer by pulling the cords can control the winch and move the dome without leaving the eye-end of the telescope in whatever position it may be. Should the water-supply be cut off from any cause, the winch drum *I* is set free by sliding the pinion *G* out of gear with *H*, and the dome is moved by the hand-rope gearing shown due west, fig. 4. An endless rope passes over the large wheel, and the cog-wheels numbered 16–72, 24–84, 17, are thrown, with No. 17, into gear with the rack upon the wall of the observatory. The stud brackets (not shown, to avoid complication) carrying the hand-gear wheels are attached to the foundation ring of the dome. By this means the dome can be easily moved through 90° by one person in 5 minutes. The rack and hand-gear might be dispensed with provided a handle within the observatory was connected by a shaft and pinion with the gearing of the winch outside.

In order to preserve the telescope from damp, hot-water pipes are brought in at the east side of the observatory under the floor and carried round the foundation of instrument, as shown in fig. 1. The circulation can be cut off at once, and the warm water in the pipes replaced by cold.

The total area for ventilation when all is open is equal to $\frac{1}{9}$th the area of the dome. The water-engine can be utilised to facilitate the ventilation of the observatory, if necessary, by driving a small fan.

The weight of the dome is about 14 tons. The weight of the platform, steps, and gallery (about $1\frac{1}{2}$ ton) is additional to this. 7 lbs. on the endless rope of the hand-gear will move the dome.

The construction and erection of the dome has been ably carried out by Messrs. Clapham Bros., of Keighley, Yorkshire, especially as it is the first astronomical dome which they have constructed.

I hope in a future paper to give some account of the telescope and its work.

Note on the visible Spectrum of the Great Nebula in Orion.
By Ralph Copeland, Ph.D.

When examined with a sufficiently powerful spectroscope provided with a slit, the light of the Great Nebula is chiefly separated into the three well-known lines characteristic of most gaseous nebulæ. There is also a fourth line, which is generally admitted to coincide in place with the third great line of the hydrogen spectrum. Towards the end of 1886, however, when the nebula was first studied at Dun Echt with an exceptionally suitable spectroscope, a long stretch of continuous spectrum was detected, embracing the three brighter lines and terminating somewhat abruptly a little above D, in W.L. 570, or thereabouts. In the dark space below this a faint but apparently well-defined line was discovered on December 28, 1886. The first measures, made two days later, indicated that its light was slightly more refrangible than that of the D-lines. It was therefore naturally thought that the line would turn out to be identical with D_3, a supposition which further observations strongly confirmed. The mean wave-length derived from over thirty measures is 587·4, or only 0·1 less than Vogel's position of D_3. The occurrence of this line in the spectrum of a nebula is of great interest as affording another connecting link between gaseous nebulæ and the Sun and stars with bright line spectra, especially with that remarkable class of stars of which the first examples were detected by MM. Wolf and Rayet in the constellation of *Cygnus*.

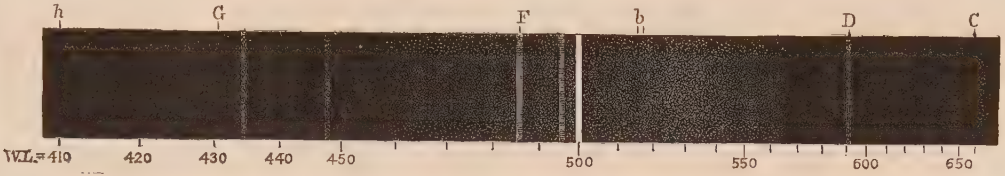
On January 23, 1887, it was believed that traces of an exceedingly faint line could be made out about W.L. 448. If a line of this refrangibility exists, it can probably be photographed more easily than seen.

The following table and diagram show the results of the measures and the general appearance of the spectrum.

Great Nebula in Orion.

	Line (5)	Meas.	(1)	Meas.	(2)	Meas.	(3)	Meas.	eF	Meas.	(4)	Meas.	Continuous Spectrum.
1886, Dec. 28	...	...	500·7	2	495·8	2	...	...	...	...	434·8	2	
30	585·5	5	...	...	...	...	...	...	...	...	...	...	
1887, Jan. 20	...	...	500·3	2	495·7	2	486·1	3	...	...	434·0	2	Begins 566·2; ends 456·1
23	588·0	8	500·3	1	496·0	1	486·1	2	447·6	1	433·9	3	Begins 564·7.
Feb. 18	589·2	10	...	...	...	...	...	...	...	...	...	...	
Mar. 19	586·9	10	...	...	...	...	...	...	...	...	...	...	
24	...	...	...	...	...	...	...	...	...	...	...	...	Begins 572.0; max. 527·5; ends 462·6
	587·4		500·4		495·8		486·1		447·6		434·2		Begins 567·6 Max. 527·5 Ends 459·4

D_3 Vogel.	D'Arrest's Mean Values.				Watts.
587·5	500·4	495·7	486·1	...	434·0



Visible Spectrum of the Great Nebula in *Orion*.

In conclusion it may be mentioned that on many favourable occasions the spectroscope was carefully adjusted for C, but no trace of that line could be detected in the light of the Great Nebula. On the other hand, the continuous spectrum shows some indications of resolvability into lines or bands.

Lord Crawford's Observatory, Dun Echt:
1888, *June* 2.

Physical Observations of Saturn in 1888.

By Thomas Gwyn Elger.

In continuation of the paper presented at the June meeting last year, I submit the following observations of the planet made with an $8\frac{1}{2}$-inch silver-on-glass reflector by Calver during the months of January, February, March, and April this year, premising that, though the weather generally was not so favourable for the scrutiny of delicate detail as during the spring of 1887, on some four or five nights the atmospheric conditions were especially excellent, and on several occasions, when they were less propitious, spells of very good vision, of longer or shorter duration, were obtained. Eyepieces magnifying 284, 340, and 420 times were employed—the second being found most usually serviceable, though the highest afforded superb views of the planet on suitable nights.

Ring A.—The colour of this ring always appeared on the best observing nights to be lavender-grey, its uniformity and depth of tone, however, varying within wide limits. On some occasions it was either wholly or partially divided, about midway between the outer and inner edge, into two zones—an outer dark zone and an inner light zone, the latter being sometimes evidently the narrower. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, with superb vision, affording long steady views with powers 340 and 420, the contrast in the shading was very marked, the southern portion from the extremities of both ansæ up to the ball being very much darker than that on the northern half of the ring. On March 21, $9^h\ 15^m$ to $10^h\ 10^m$, it was clearly darker on the *p.* ansa, as was also the case on March 27, $8^h\ 15^m$ to $8^h\ 50^m$. On inferior nights a ruddy or salmon hue was frequently noted in connection with this ring—an appearance which was probably due to atmospheric causes. *Divisions.*—Though a faint, delicate, dark line, presumably Encke's division, was frequently observed last year, even on indifferent nights, not a trace of any dark division was seen this season, except on March 6, 8^h to 9^h, and on March 21. On the former date a faint dark line was glimpsed on the *s. f.* side, and on the latter, between $9^h\ 15^m$ and $10^h\ 10^m$ a similar feature was seen on the *p.* ansa, at a distance of about one-third the width of the ring from its outer edge. A narrow light streak (as was

the case last year) was frequently observed, but on no occasion traced all round. On February 11, $9^h\ 30^m$ to $10^h\ 5^m$, it was seen on the northern side of the *p.* ansa; on February 12, $8^h\ 30^m$ to $9^h\ 10^m$, it was visible for a considerable distance, both on the north and south sides of the *p.* ansa. On March 3, $8^h\ 15^m$ to $9^h\ 15^m$, it was seen well on the *p.* ansa, and less distinctly, near the extremity of the *f.* ansa. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, it was only traceable on the north side of *p.* ansa. On the following night, 8^h to 9^h, it was once more visible on both ansæ, as on March 3—a faint dark line being noted *s. f.*, as mentioned above. On April 6, 9^h to $9^h\ 45^m$, the light strip was seen *s. p.* It was generally estimated to be rather nearer the outer than the inner edge, though on one or two occasions, notably on February 12, it seemed to be nearer the latter.

Cassini's Division.—This dark band has never impressed me as being perfectly black, or, except as regards its inner edge, well defined. On February 10, $8^h\ 45^m$ to $9^h\ 30^m$, its outer margin on both ansæ seemed "fuzzy," and without any definite limit. The same appearance was noted still more distinctly on February 12, $8^h\ 30^m$ to $9^h\ 10^m$, when ill-defined feathery projections seemed to extend from the outer edge, on E ansa, on ring A. Definition was very good, permitting these features to be steadily seen with both powers, 340 and 420, for some time. On March 5, a still more favourable night, the outer edge was recorded as very badly defined, and projections again noted *s. f.* On subsequent occasions, notably on March 6, 8^h to 9^h, and on March 27, $8^h\ 15^m$ to $8^h\ 50^m$, an evident want of sharpness and distinctness was again remarked in connection with this edge. On many nights, more especially on February 12, March 3, 6, and 21, there was a marked difference between the visibility of the Cassini division on the south and north. From the extremity of either ansa towards the south and up to the ball, it was very much darker than round the north side, where it was scarcely visible at all.

Ring B.—The gradual gradation of shade from the dark inner edge of this ring to the bright zone bordering its outer edge, which was so marked a characteristic on almost every fine night during the early months of last year, has not been on any occasion prominent. The brilliant outer zone, however, has not only given one the impression of being more bright and conspicuous, but has exhibited distinct inequalities in brightness on different segments. On February 7, 9^h to $9^h\ 30^m$, February 10, $8^h\ 45^m$ to $9^h\ 30$, February 11, $9^h\ 30^m$ to $10^h\ 5^m$, February 12, $8^h\ 30^m$ to $9^h\ 10^m$, and March 3, $8^h\ 15^m$ to $9^h\ 15^m$, it was noted as being much more brilliant on the *f.* than on the *p.* ansa. On February 12 this difference in brightness was so remarkable that it could hardly be overlooked by anyone at all accustomed to the examination of planetary detail. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, it was noted as very brilliant on *s. f.* ansa, less conspicuously so *n. f.*

and *s. p.*, and scarcely traceable *n. p.*, its colour, yellowish white, contrasting with every other feature of the planet. On March 21, $9^h\ 15^m$ to $10^h\ 10^m$, on the contrary, it was brightest on the *s. p.* side, and generally bright on the *p.* side, while it was only just traceable on the opposite ansa. On March 27, $8^h\ 15^m$ to $8^h\ 50^m$, it appeared to be equally brilliant all round. On April 6, 9^h to $9^h\ 45^m$, it was, once more, distinctly brighter on the *f.* side. The width of this brilliant rim was estimated on some nights as being as much as $\frac{1}{3}$, on others as little as $\frac{1}{5}$, the total width of B. No great weight, however, can be given to eye-estimations in this case, as the inner edge of the bright zone was sometimes scarcely distinguishable from the neighbouring portion of the ring The delicate rounding off of the shading from within to the outer bright zone, sometimes giving B the appearance of a solid ring, circular or elliptical in cross-section, which was so remarkable last year, was far less pronounced this season, when on some nights, definition being nearly all that could be desired, with the exception of a dusky crescent-shaped border on one or other of the ansæ, scarcely any difference in depth of tone could be noted in the region between the inner edge of B and that of the brilliant zone on the outer edge of the ring. The widest part of the crescent-shaped shading just mentioned on the inner border of B was at the extreme ends of the ansæ, and was estimated to be about $\frac{1}{4}$ the width of the ring. Its outer limit did not appear to be concentric with the ring, but curved more rapidly, so that this uniformly dusky band died out apparently on either side about midway between the major axis of the ring and the ball. When seen at all, it was generally remarked on the *f.* ansa, and only twice on the *p.* side. It was very distinct on February 10 and 12, March 3, 5, 21, and 27 (all favourable nights) on the *f.* side, and on April 6 and 8 on the *p.* side. On none of these occasions could a trace of a similar band be detected on the opposite ansa.

Ring C.—During the time that this ring was under observation last year, it was generally recorded as more or less dark in tone on both ansæ. The first satisfactory view of it obtained this season (January 29, $8^h\ 40^m$ to $9^h\ 25^m$) exhibited it as light grey in colour on the *p.* ansa, and much more distinct than it was at any time when viewed in the previous year. Its inner edge seemed perfectly regular, and its surface even in tone, except *s. p.* (near the ball), where it appeared to be somewhat darker than elsewhere. The *f.* ansa, however, presented a striking contrast in every respect. Here it was dark and scarcely traceable, and appeared to be separated from B by a narrow sharp dark line all round. On subsequent nights the following observations were recorded:—

February 1, 10^h to $10^h\ 25^m$.—On *p.* ansa light, and greyish in tone. Very obscure on *f.* ansa. Powers 340, 420.

February 3, $7^h\ 30^m$ to 8^h.—Variable definition. Light on *p.* ansa, scarcely visible on *f.* ansa. Power 284.

February 7, 9^h to 9^h 30^m.—Variable definition with occasional steady glimpses. Light grey on *p.* ansa. Inner edge apparently regular. Width estimated as equal to half the space between inner edge of ring and ball. On *f.* ansa very obscure—difficult to make anything of it. Inner edge nowhere traceable. Powers 284, 340.

February 10, 8^h 45^m to 9^h 30^m.—Definition very good at times. Divided from B by a distinct black line, visible only on west ansa. Very obvious and light on *p.* ansa, except on south side for some distance west of the ball, where it was manifestly darker than elsewhere. On *f.* ansa it was dark and only visible in places. At times the inner edge seemed to be indented, but of this I could not be sure as it was so badly defined. Powers 280, 340.

February 11, 9^h 30^m to 10^h 5^m.—Good definition. As on the 10th in *p.* ansa. In *f.* ansa very dark and indistinct. Even at times of best seeing I could only trace the *s. f.* portion of it, the remainder being apparently as dark as the space between the ball and the ring. Powers 284, 340, 420.

February 12, 8^h 30^m to 9^h 10^m.—Good definition. Rather dark, but apparently normal in *p.* ansa. Unequally dark, patchy, in *f.* ansa. The inner edge only visible on *s. f.* side. Powers 340, 420.

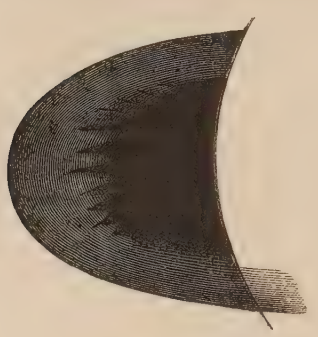
March 3, 8^h 15^m to 9^h 15^m.—Good definition. Rather dark in *p.* ansa. Estimated breadth less than space between inner edge and ball. A distinct dark patch, like a notch, visible near the middle of the ansa, broadest on the face of ring, and extending nearly from the inner to outer edge. On *f.* ansa still very dark—only traceable on *s. f.* side. Powers 340, 420.

March 5, 7^h 35^m to 9^h.—Very favourable night, affording splendid glimpses of the planet of long duration. Ring divided from B on *f.* side by a well-defined black space, traceable all round ansa. A similar but broader division noted *s. p.*, being broadest where it abuts on west limb of *Saturn*. In this ansa, however, it cannot be traced on *n. p.* side. Ring somewhat lighter on *p.* than on *f.* ansa, but dark on both. On the former, the dusky spot, seen on March 3, is observed with all the eyepieces, and three or more dark areas are noted on *s.* side of *f.* ansa. Ring not traceable *n. f.* That part of the ring in front of the ball is only slightly darker than dark belt south of the equator and is lighter than any portion of ring A. The limb is visible through it, and it seems wider on the *f.* than on the *p.* side, but as the inner edge is difficult to distinguish from the faint belt behind it, this is doubtful. Powers 284, 340, 420.

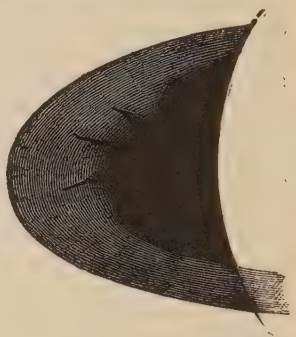
March 6, 8^h to 9^h.—Definition not so good as on the 6th, though at times favourable glimpses were obtained. During a spell of good vision after 8^h 30^m I again saw the dusky spot on *p.* ansa, and three or more on south side of *f.* ansa. Powers 340, 420.

March 10, 10^h to 10^h 20^m.—Though an unfavourable night, the difference in depth of tone of the surface on both ansæ was

quite apparent. The ring seemed to be lighter on *p.* ansa, and broader than space between inner edge and ball. Power 340.



Ring C, March 21.



Ring C, March 27.

March 21, $9^h\ 15^m$ to $10^h\ 10^m$.—Definition steady, vision good. Inner edge ragged and clearly indented on *p.* side, but indentations not very deep. The ring uneven in colour, though no distinct spots could be made out. On *f.* ansa it was only visible on north side. Powers 340, 420.

March 27, $8^h\ 15^m$ to $8^h\ 50^m$.—Definition fairly good. Much lighter on *p.* than on *f.* ansa, where it is scarcely traceable, except on the north side. Inner edge on *p.* ansa scalloped, exhibiting three or four convex projections, and dark patches visible on its surface. Very light where it passes in front of ball. Powers 340, 420.

March 28, $9^h\ 30^m$ to $10^h\ 10^m$.—Definition moderate. Light on *p.*, but obscure on *f.* ansa. Scalloped edge again noted on *p.* ansa, one projection, near the centre, being especially deep and prominent. Powers 284, 340, 420.

April 6, $9^h\ 0^m$ to $9^h\ 45^m$.—Definition variable. Very light and distinct on *p.* ansa, though somewhat dark on the south near the ball. Scalloped edge again satisfactorily seen with all the powers. Very obscure on *f.* ansa. In front of ball it is certainly wider on *f.* than on *p.* side, as was suspected on March 5. Powers 284, 340, 420.

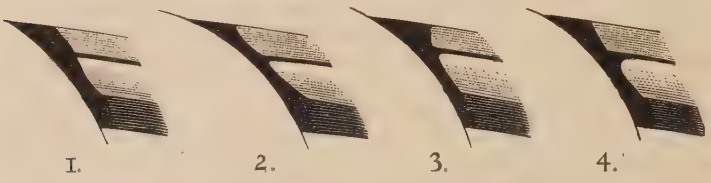
Belts.—A very marked change both in number, position, and visibility, especially obvious in the region between the South Polar Cap and the dark band south of the bright equatorial zone, has taken place among these delicate features since they were last observed in 1887, tending to show, if it were needed, that the fainter belts are subject to variations, similar in appearance, if not in character, to those noted in connection with the fainter cloud belts of *Jupiter*; while the wide bright equatorial band and the dark belt south of it, though apparently even more persistent than the grosser bands on this planet, would, if it were

possible to examine them under equally favourable conditions, display the same kind of mutability as regards hue and detail. Last year the region south of the bright equatorial zone was marked by a more or less dusky zone, generally recorded as ruddy in colour, and extending to nearly $\frac{1}{3}$ of the apparent distance between the equator and the south limb, and frequently exhibiting long narrow rifts too ill-defined to represent or describe. It was bordered on the north by the darkest and broadest belt on the disc, and on the south by a band nearly as wide but less pronounced. This year this intermediate dusky zone was no longer visible as before, and though the belt which bounded it on the north was still the darkest on the planet, that on the south was only traced as an extremely faint object on the best nights, and was frequently not seen at all, even when atmospheric conditions were favourable.

The belts were usually recorded as follows, commencing from the inner edge of ring C, where it passes in front of the ball:—(1) a faint nebulous band, on some nights scarcely distinguishable from C. Frequently seen to the best advantage near the east and west limb of the planet, where, through the effect of perspective, it appears to rise above the edge of C. (2) A broad bright zone of yellowish hue, generally estimated to be the brightest feature in connection with the planet, extending to a little south of the equator. It was occasionally seen to be mottled with delicate white fleecy spots. (3) A more or less dark band (greyish blue) scarcely $\frac{1}{5}$ the width of 2. Sometimes well-defined on both edges, but far more often noted as harder and sharper on the north than on the south. (4) A greyish region, answering to the dusky ruddy zone seen last year. (5) A very faint belt, representing that which then formed the southern limit of 4, sometimes only partially visible, at other times not seen at all. (6) A uniformly grey region (on which faint belts were occasionally detected), extending to the northern edge of Polar Cap.

On several nights, when definition was favourable, the northern half of bright zone (2) seemed to be distinctly duller than that adjoining 3—notably on March 5—as if a faint broad belt existed between it and 1. Belt 3, on January 29 and February 3, was dark, and sharply defined on both edges. On February 10 it was more sharply defined on the north than on the south, and was estimated as equal in tone to the outer zone of ring A. On February 11 the southern edge was very nebulous. On February 12 both edges were badly defined. On March 21 it was very hard and sharp on the north, while the south edge was ragged. The greyish-blue South Polar Cap appeared to vary in darkness considerably on different nights. From January 17 to February 1 it was recorded as very dusky, but subsequently, from February 3 until March 5, as very light, on some nights scarcely differing in tone from the zone north of it. On the latter date it was very dark near the limb. On

March 21 and 27, it was again described as light. On March 28, $9^h\ 30^m$ to $10^h\ 10^m$, as being decidedly darker on the *f.* side, by the limb, than elsewhere. On April 6 it was of an even grey colour. Detail in the form of ill-defined light markings was frequently seen on band 4, which sometimes seemed to be of a warm ruddy hue. On February 10, at 9^h, a faint narrow band was observed south of 5, which seemed to be slightly inclined to it. On January 29, 5 was only traced from the east limb to about the middle of the disc. The *colour of the ball*, like that of the rings, seems to be a matter depending very much upon the quality of the night. On the best occasions, the yellowish tone of the equatorial region, the pale cinnamon hue of that extending south of the greyish-blue belt, 3, the dull grey of the region south of this, and the lighter bluish-grey or slaty tone of the Polar Cap, were manifest; while on inferior nights the cinnamon hue gave place to a ruddy colour, and the bluish tone of the duskier feature, was far less noticeable.



Shadow of Ball on Rings.—Only two nights were available before opposition on which it was possible to examine the shadow of the ball. On January 9, 9^h to $9^h\ 30^m$, power 340, it was well seen on the *p.* side, and recorded as concentric with the ball. On January 17, $8^h\ 20^m$ to $8^h\ 45^m$, it appeared to be slightly concave on both rings, A and B. It was rather wider south than north, and did not seem so black as the sky or the space between C and the ball. No notch or projection was seen on either evening. On January 29, $8^h\ 40^m$ to $9^h\ 25^m$ (rather more than six days after opposition), and on February 3, $7^h\ 30^m$ to 8^h, the shadow (on *f.* side) was noted as slightly concave, no visible notch or projection being visible with any power. On February 7, 9^h to $9^h\ 30^m$, it was distinctly concave on B up to Cassini's division, but convex on A (fig. 1). On February 10, $8^h\ 45^m$ to $9^h\ 30^m$, it was slightly concave on both rings, with a slight projection at Cassini's division;—seen well with 340 and 420. On February 11, $9^h\ 30^m$ to $10^h\ 5^m$, difficult to detect any concavity in the outline of shadow; notch just glimpsed two or three times. February 12, $8^h\ 30^m$ to $9^h\ 10^m$, slightly concave on A and B, with a notch at Cassini's division. Shadow very black and sharp; traceable on surface of C (fig. 2).

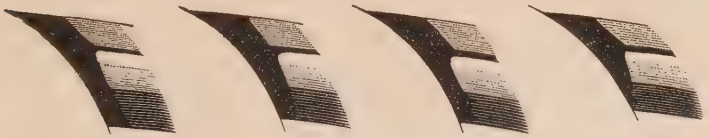
March 3, $8^h\ 15^m$ to $9^h\ 15^m$.—There appears to be a difference in the curvature of boundary of shadow on rings B and A, though it is concave on both. The shadow on B is part of a flatter curve than that on A, the latter widening considerably towards

the edge of the ring. Notch at Cassini's division well seen (fig. 3).

March 5, $7^h\ 35^m$ to 9^h.—Very slightly concave. At times seemed (as on the 3rd) rather more concave on A. Broadest towards the south. Notch at Cassini's division acute and long, appearing to extend some distance along it (fig. 4).

March 6, 8^h to 9^h.—Concave on A and B. Width of shadow in narrowest part equal to $\frac{2}{3}$ of ring A at this place. Notch distinct with all powers.

March 21, $9^h\ 15^m$ to $10^h\ 10^m$.—Very sharp and black, slightly concave on B, but appears to follow the curvature of the ball on A. Easily traced on C. Notch evident, but blunt (fig. 5).



5. 6. 7. 8.

March 27, $8^h\ 15^m$ to $8^h\ 50^m$.—Shadow nearly concentric with ball, but rather wider towards the south. Notch blunt, but obvious (fig. 6).

March 28, $9^h\ 30^m$ to $10^h\ 10^m$.—Shadow, ? slightly concave on B, straight on A. Notch evident (fig. 7).

April 6, 9^h to $9^h\ 45^m$.—? Slightly concave on B, with a blunt protuberance at Cassini's division (fig. 8). April 8, 9^h to $9^h\ 30^m$, as on the 6th.

April 11, $9^h\ 15^m$ to $9^h\ 30^m$.—Though the night was not very favourable, good views were occasionally obtained of the shadow with powers 284 and 340. It appeared to be very distinctly concave both on B and A, the curve on both rings running up to end of notch, which was very blunt.

The objective reality of some of the features just described has, in one or two quarters, been called in question, and an endeavour made to explain them away by suggesting that they are due either to bad definition, distorting eyepieces, or defective vision. No doubt these evils, individually and in combination (especially when associated with a lively imagination), have, ere now, been answerable for the production of remarkable results; but, as regards the foregoing observations, the first two may at once be ignored; as the abnormal appearance of ring C, the peculiarities of the shadow of the ball, and other delicate details were invariably seen to greater advantage in proportion to the goodness of the night for observing purposes; indeed it was, with one or two exceptions, only on favourable nights that it was possible to see the dark areas and ragged edge of A at all. With respect to the eyepieces, they are excellent specimens of the optical skill of the late Mr. Cooke, giving good results on other celestial objects—whether double stars, *Jupiter*, or the Moon—

hence it is inconceivable that they should go wrong on *Saturn*. Only the last objection, therefore, remains—a personal one—defective vision. This, if it has weight in this particular case, would also apply to many who are reckoned as highly-skilled observers. I may especially signalise M. Trouvelot and Dr. Terby. The former, in a valuable paper on *Saturn* (*Comptes rendus*, t. xcviii. p. 968), sums up the results of his own observations with the remark:—"*Les anneaux de cette planète, loin d'être stables, sont, au contraire, essentiellement variables et subissent des changements continuels.*" Since this was written, in 1884, much additional evidence has been forthcoming to support its truth. The existence of *masses sombres* on ring C was announced last year by Dr. Terby, and of indentations on its inner edge by myself; while equally remarkable appearances were recorded by MM. Stroobant and Stuyvaert with the 15-inch equatorial of the Brussels Observatory. This year Dr. Terby has again seen abnormal features. They have also been noted by Major Watson, who has observed dark patches on both ansæ and a serrated edge to ring C, with his fine 13-inch With mirror, at Newbridge, Ireland; by Rev. P. H. Kempthorne, M.A., of Wellington College, who has seen both spots and indentations in connection with C, with an $8\frac{1}{2}$-inch With; and also by M. Gaudibert with an $8\frac{1}{2}$-inch reflector, at Vaison, Vaucluse.

It is perhaps noteworthy that those, with sufficient optical means, who do *not* see them, are more or less desultory observers of the planet, while those just mentioned examined it on every available opportunity. Continuous observation, night after night, doubtless tends to educate the eye, so that it soon becomes so familiar with the object scrutinised, that delicate features, which are either only doubtfully glimpsed or not seen at all by the occasional gazer, are readily detected whenever definition permits.

No telescope of the largest type has of late, so far as I know, been brought to bear upon the rings of *Saturn*. It is to be hoped that this will be done before they become too unfavourably placed for the detection of abnormal details.

Kempston, Beds:
1888, *May* 31.

Observations of Sappho (80). By Professor C. H. F. Peters.

On account of the state of the weather I have not succeeded in obtaining more than the following observations. They are made with the filar micrometer of the 13-inch refractor, power 270, bright wires in dark field. The differences between star and planet have been corrected for refraction.

	H. C. Mean Time. h m s	Δα. m s	Δδ. ″	No. comp.	App. α. h m s	Log. f.p.	App δ. ° ′ ″	Log. f.p.	Comp. ✶
1888, April 3	9 8 44	+0 55·86	+3 57·0	10	13 28 23·30	9·5447*n*	−13 36 21·6	0·8311	*a*
4	10 43 35	+3 23·48	−2 44·2	12	27 25·33	9·3057*n*	13 28 9·9	0·8566	*b*
6	12 23 57	−1 19·90	+1 43·4	15	25 32·39	7·5985	13 11 51·0	0·8644	*c*
8	12 44 15	−1 37·01	−3 11·6	11	23 41·03	8·7924	12 55 32·8	0·8628	*d*

The positions of the comparison stars for 1888·0 are adopted as follows:

	h m s	° ′ ″	
a	13 27 26·18	−13 40 13·9	(Red. to app. place + 1ˢ·26; −4″·8.) Mean of
	26·06	14·8	W. 13ʰ·422, incl. syst. corr. −0ˢ·01; +1″·2.
	26·31	13·0	Sant. (IV.) 1244, incl. syst. corr. +0ˢ·13; +0″·5.
b	13 24 0·57	−13 25 20·7	(Red. +1ˢ·27; −5″·0.) Mean of
	0·59	20·8	W. 13ʰ·356, incl. syst. corr. −0ˢ·01; +1″·2.
	0·56	22·2	Lam. 1326, incl. syst. corr. +0ˢ·05; +0″·7.
	0·55	19·0	Sant. (IV.) 1241, incl. syst. corr. +0ˢ·13; +0″·5.
c	13 26 51·01	−13 13 29·3	(Red. +1ˢ·28; −5″·0.) Mean by weight of
	51·06	31·8	w. 1, W. 13ʰ·412, incl. syst. corr. −0ˢ·01; +1″·2.
	51·10	28·8	w. 2, Altona, *A. N.* vol. xxxiv. (Kam, 2479.)
	50·90	28·6	w. 2, Sant. (IV.) 1243, incl. syst. corr. +0ˢ·13; +0″·5.
d	13 25 16·75	−12 52 16·0	Cordoba Gen. Cat. 18396. (Red. to app. place +1ˢ·29; −5″·2.)

For this last star we find the following older determinations (syst. corr. not included):

	h m s	° ′ ″
LL. 24990	13 25 17·56	−12 52 11·6
W. $13^{h}\cdot378$	17·45	13·8
Lam. 1328	16·74	14·9
Sant. (III.) 1550	16·98	17·0

which perhaps indicate a slight proper motion.

On April 6 I have used a star different from the one suggested by Mr. Bryant, since the distance in declination of DM. $-12°\cdot3834$ (in *Monthly Notices* xlviii. p. 96, the minute of R.A. should be 26^{m} instead of 25^{m}) from the planet became inconveniently large for our meridian.

The comparison of the observations with Mr. Bryant's ephemeris, employing the annexed parallaxes, gives the following corrections O−C:

	Parallax.		Corr. Δα.	Corr. Δδ.
	s	″	s	″
April 3	−0·21	+4·0	+6·86	−29·5
4	−0·12	+4·2	6·44	31·1
6	0·00	+4·3	6·69	32·8
8	+0·04	+4·3	6·74	33·9

Litchfield Observatory of Hamilton College, Clinton, N.Y.:
1888, *May* 8.

Observations of Comet a 1888 (*Sawerthal*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination.

Comet a 1888 (*Sawerthal*).

Greenwich Mean Solar Time.	Observer.	✱−✱ R.A.	Corr. for Par. and Refraction in R.A.	✱−✱ N.P.D.	Corr. for Par. and Refraction in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	Comp. Star.
1888 d h m s		m s	s	′ ″	″		h m s	o ′ ″	
May 11 14 30 1	H. T.	−1 15·22	−0·30	+ 8 12·7	−3·0	6	23 48 25·58	57 52 13·4	*a*
12 13 45 29	T.	−0 36·39	−0·30	+ 1 8·1	−3·6	9	23 50 25·31	57 26 15·4	*b*
13 58 11		+0 11·25	−0·30	+10 41·0	−2·8	2	...	...	*c*
13 13 17 10	H. T.	+2 3·35	−0·30	− 7 48·0	−5·1	4	23 52 28·55	57 0 27·3	*d*
13 18 22		+3 49·12	−0·32	− 1 23·6	−4·1	5	23 52 30·10	57 0 29·3	*e*
13 28 27		−1 15·20	−0·37	+ 6 16·4	−3·1	3	23 52 31·03	57 0 12·9	*f*
15 13 28 56	H. T.	−2 21·50	−0·30	+11 8·1	−3·0	3	23 56 35·90	56 9 28·0	*g*
18 12 29 10	H. T.	−1 16·48	−0·30	− 0 22·3	−4·1	6	...	...	*h*
23 12 24 12	T.	+0 7·25	−0·30	− 2 24·3	−4·6	8	...	...	*i*
31 12 44 43	H. T.	+1 14·63	−0·30	+ 1 34·5	−3·2	4	0 25 41·23	50 16 42·6	*j*
12 48 34		+1 7·93	−0·30	− 5 59·7	−3·8	6	...	...	*k*
12 56 17		−1 48·90	−0·30	−14 17·6	−4·3	2	0 25 39·90	50 16 35·5	*l*
June 3 13 27 45	H. T.	+1 29·10	−0·30	+ 4 14·7	−2·6	1	0 30 26·90	49 19 9·0	*m*
6 11 37 2	H. T.	−0 25·92	−0·20	+ 0 9·5	−3·6	6	...	...	*n*

Mean Places of Comparison Stars.

	Star's Name.	R.A., 1888·0. h m s	N.P.D., 1888·0. ° ′ ″	Authority.
a	Lalande 46883	23 49 41·57	57 43 51·8	Second Armagh Catalogue.
b	W. B. (2) XXIII. 1029	23 51 2·42	57 24 59·0	Weisse's Bessel (2).
c	Arg. Zone +32°, No. 4736	23 50 16	57 17	Bonn Observations, Vol. IV.
d	W. B. (2) XXIII. 1020	23 50 25·91	57 8 8·5	Second Armagh Catalogue.
e	W. B. (2) XXIII. 989	23 48 41·71	57 1 45·1	Weisse's Bessel (2).
f	Lalande 47034	23 53 47·05	56 53 47·7	Greenwich Observations, 1880.
g	W. B. (2) XXIII. 1243–4	23 58 58·15	55 58 8·3	Weisse's Bessel (2).
h	Arg. Zone +34°, No. 5	0 3 47	54 57	Bonn Observations, Vol. IV.
i	Arg. Zone +36°, No. 25	0 11 50	53 5	Bonn Observations, Vol. IV.
j	W. B. (2) 0, 570	0 24 26·97	50 14 59·0	Weisse's Bessel (2).
k	Anonymous			
l	W. B. (2) 0. 656–7	0 27 29·16	50 30 45·1	Second Armagh Catalogue.
m	W. B. (2) 0. 689	0 28 58·05	49 14 44·6	Weisse's Bessel (2).
n	Arg. Zone +41°, No. 109	0 35 14	48 25	Bonn Observations, Vol. V.

Notes.

May 11.—Comet faint. Could only be observed by averted vision. A good deal of haze. Tail traceable for about 4′.
May 12.—Comet very faint.
May 23.—Comet has well-defined nucleus equal to 4th or 5th magnitude star, showing brightly in strong moonlight. No tail visible.
May 31.—Comet about as bright as a 7th magnitude star.
June 3.—Comet a little fainter than a 7·5 magnitude star.
June 6.—Comet about as bright as a 9th magnitude star.

The observations are corrected for parallax and refraction.
The initials H. T., T. are those of Mr. Turner and Mr. Thackeray respectively.

Observations of Comet a 1888 (*Sawerthal*), *made at the Radcliffe Observatory, Oxford.*

(*Communicated by E. J. Stone, M.A., F.R.S., Radcliffe Observer.*)

The following observations of Comet Sawerthal were made with the Barclay Equatorial, using the ring micrometer with power 100.

1888.	G.M.T.	Comet—Star (Corrected for Refraction only) Δ R.A.	Δ N.P.D.	Comparisons.	Apparent R.A. of Comet.	Log ($p \times \Delta$)	Apparent N.P.D of Comet.	Log ($p \times \Delta$)	Observer.
	h m s	m s	′ ″		h m s		° ′ ″		
May 23	12 43 23	+4 57·27	+6 32·80	8	0 11 58 01	9·3698	53 2 30·58	0·5679	R.

Assumed Place of Comparison Star (*Lalande* 89).

Mean R.A. 1888·0.	Reduction to Apparent Place.	Mean N.P.D. 1888·0.	Reduction to Apparent Place.
h m s	s	° ′ ″	″
0 7 0·96	−0·22	52 55 45·56	+12·22

Authority.

Mean of Radcliffe observations, 1873, 1874, and 1875.

Observer's Remarks.

The coma of Comet is nearly 3′ broad (having widened considerably since May 2), and resembles a pair of wings. The following half of the nucleus forms a well-defined and bright semicircular disc, the preceding part gradually fading down until lost in the nebulosity of the coma. With power 100 the nucleus is equal in brightness to the star near (Arg. Z. + 36°, No. 25), or 8·7 mag., but in the 3-inch finder is nearly as bright as the comparison star (Lalande 89), or 6·8 mag. A faint streak of the tail is visible, and is about 2′ in length. Strong moonlight.

Sketch of Comet *a* 1888 (Sawerthal), May 23, $12^h\,45^m$ G.M.T. Drawn by Mr. W. H. Robinson, using the Barclay Equatorial, with power 180. (The Star near is Arg. Z. + 36°, No. 25.)

Observation of Comet a 1888 (*Sawerthal*), *made at Launceston, Tasmania.* By A. B. Biggs.

Comet from Star Σ 2878. *Comet N.P.*

1888.	Greenwich Mean Time.	Diff. R.A.	Diff. N.P.D.	No. of Measures.
	d h m s	s	′ ″	
April	5 7 33 6	−55·25	−2 23·8	4 (all good).

Brightness, ∠ star.

Note.—The whole figure appeared to have assumed quite a ruddy tint as compared with its former appearance—possibly atmospheric, but I think not.

Telescope ($8\frac{1}{2}$-inch reflector) previously readjusted.

Observations of Comet a 1888 (*Sawerthal*), *made at Windsor, N. S. Wales.* By John Tebbutt.

The comet, the news of the discovery of which reached me on February 23, has been observed by me on every occasion when the weather permitted. It has throughout been distinctly visible to the unassisted eye, and its nucleus, till towards the close of the period of observation, was brilliant and star-like, and therefore was adapted for accurate pointing. During the last few days the nucleus was considerably elongated, but the point of greatest brightness was clearer for observation. All the positions depend on filar-micrometer comparisons. The first positions for March 7 and 14 were obtained with the $4\frac{1}{2}$-inch and all the rest with the 8-inch equatorial. Fog or cloud has prevented any observation since the morning of the 3rd instant.

Comet a 1888.

1888.	Windsor Mean Time.	Comet — Star. Δ R.A.	Δ N.P.D.	Comps.	Comet's App. R.A.	Log $\frac{p}{P}$	Comet's App. N.P.D.	Log $\frac{q}{P}$	Red. to App. Place.		Comp. Star.
	h m s	m s	′ ″		h m s	−	° ′ ″	+	s	″	
Feb. 27	16 35 34	+ 0 33·93		17	20 2 10·75	8·8746			−2·00		1
27	16 35 34	− 0 5·13	+ 7 21·6	17	20 2 10·93	8·8746	134 20 28·2	9·3789	−2·01	−6·0	2
28	16 34 30	+ 2 13·81	−13 52·0	4	20 6 53·64	8·8651	132 52 32·8	9·4104	−1·95	−5·7	3
Mar. 2	16 26 47	− 0 46·42	+ 2 5·1	9	20 20 1·47	8·8401	128 24 19·1	9·5023	−1·81	−4·0	4
2	17 9 9	− 7 22·11	− 6 48·6	3	20 20 13·75	8·8138	128 21 26·3	9·3576	−1·85	−3·6	5
3	16 42 37	+15 13·61	+ 4 32·6	5	20 24 18·09	8·8234	126 52 7·3	9·4740	−1·69	−4·5	6
3	16 42 37	+ 9 53·77	− 5 31·8	5	20 24 17·93	8·8234	126 52 6·9	9·4740	−1·72	−4·2	7
4	16 35 54	+11 46·48	− 8 5·3	5	20 28 18·57	8·8187	125 21 6·2	9·5123	−1·67	−3·8	8
6	17 8 19	− 0 56·62	− 4 33·3	13	20 36 9·65	8·7818	122 15 14·2	9·4653	−1·65	−2·2	9
7	15 22 27	+ 1 7·90	− 3 5·5	7	20 39 38·31	8·8103	120 49 50·3	9·6974	−1·60	−1·9	10
7	16 43 48	+ 1 20·73	− 8 16·4	21	20 39 51·14	8·7915	120 44 39·4	9·5430	−1·60	−1·9	10
8	16 49 29	− 0 11·15	− 2 15·4	18	20 43 32·88	8·7812	119 12 14·6	9·5468	−1·57	−1·4	11
9	16 46 4	+ 3 48·90	...	9	20 47 9·81	8·7768	...	...	−1·52	...	12
9	16 46 4	+ 2 19·53	+ 0 46·1	9	20 47 9·57	8·7768	117 40 26·7	9·5688	−1·52	−1·0	13
9	16 46 4	+ 0 51·06	...	9	20 47 9·51	8·7768	...	...	−1·53	...	14
10	16 58 56	+ 8 8·05	− 3 42·3	5	20 50 45·18	8·7621	116 7 54·9	9·5600	−1·46	−0·9	15
11	17 14 58	+ 6 52·63	− 6 36·3	5	20 54 17·59	8·7434	114 35 33·8	9·5487	−1·44	−0·4	16
11	17 14 58	+ 5 34·69	...	5	20 54 17·90	8·7434	...	...	−1·44	...	17
11	17 14 58	+ 3 49·73	...	5	20 54 17·54	8·7434	...	...	−1·45	...	18

1888.	Windsor Mean Time.	Comet — Star. Δ R.A.	Comet — Star. Δ N.P.D.	Comps.	Comet's App. R.A.	Log $\frac{p}{P}$	Comet's App. N.P.D.	Log $\frac{q}{P}$	Red. to App. Place.		Comp. Star.
	h m s	m s	′ ″		h m s	−	° ′ ″	+	s	″	
Mar. 14	16 21 0	+ 6 26·13	− 9 44·0	5	21 4 26·58	8·7628	110 8 6·9	9·6604	−1·35	+0·8	19
14	17 19 48	+ 6 34·09	−13 21·2	5	21 4 34·54	8·7234	110 4 29·7	9·5896	−1·35	+0·8	19
15	17 19 18	− 3 43·17	+ 8 28·2	8	21 7 55·86	8·7194	108 35 43·4	9·6047	−1·36	+1·7	20
17	17 13 51	+ 5 1·16	+ 2 56·4	9	21 14 32·66	8·7164	105 41 9·6	9·6361	−1·28	+2·1	21
17	17 13 51	− 0 44·61	...	9	21 14 33·10	8·7164	...	...	−1·30	...	22
18	17 16 59	+ 0 38·15	...	9	21 17 50·15	8·7101	...	...	−1·27	...	23
18	17 16 59	− 3 24·47	+10 38·8	9	21 17 49·98	8·7101	104 15 4·3	9·6447	−1·28	+2·9	24
19	17 31 54	+ 0 49·03	+14 59·1	9	21 21 7·85	8·6913	102 49 19·3	9·6464	−1·24	+3·1	25
21	16 57 11	− 0 2·45	− 4 0·8	5	21 27 31·69	8·7184	100 5 23·5	9·6874	−1·21	+3·7	26
21	17 27 3	+ 2 1·73	−10 20·4	6	21 27 35·84	8·6909	100 3 40·6	9·6720	−1·20	+3·7	27
25	17 35 58	− 0 8·27	+ 8 49·1	13	21 40 22·62	8·6721	94 47 33·8	9·7084	−1·13	+5·1	28
28	17 31 52	+ 5 20·67	− 1 42·9	4	21 49 49·05	8·6593	91 5 59·7	9·7333	−1·06	+5·8	29
29	17 34 32	+ 0 48·44	− 1 8·5	6	21 52 56·55	8·6683	89 54 56·0	9·7412	−1·06	+6·2	30
29	17 34 32	− 2 23·55	− 1 4·6	6	21 52 56·48	8·6683	89 55 0·5	9·7412	−1·07	+6·2	31
31	17 38 38	− 4 17·68	−11 27·3	5	21 59 9·23	8·6614	87 37 29·6	9·7555	−1·05	+6·8	32
Apr. 1	17 38 25	− 0 57·91	+12 21·3	7	22 2 14·25	8·6610	86 31 7·9	9·7621	−1·02	+7·0	33
1	17 38 25	− 2 5·42	...	7	22 2 13·85	8·6610	...	...	−1·03	...	34
2	17 40 30	+ 5 17·64	− 3 19·1	3	22 5 18·45	8·6577	85 26 8·7	9·7687	−0·99	+7·1	35
2	17 40 30	+ 4 24·02	...	3	22 5 18·11	8·6577	...	...	−0·99	...	36

Adopted Mean Places of the Stars of Comparison for 1888·0.

Comp. Star.	Mean R.A. h m s	Mean N.P.D. ° ′ ″	Authority.
1	20 1 38·82	134 14 28·6	Stone 10799.
2	20 2 18·07	134 13 12·6	Stone 10803.
3	20 4 41·78	133 6 30·5	Stone 10820.
4	20 20 49·7	128 22 18	Anonymous=8 mag. (Approx. position)
5	20 27 37·71	128 28 18·5	Stone 10965.
6	20 9 6·17	126 47 39·2	Stone 10840.
7	20 14 25·88	126 57 42·9	Cordoba Zone, 22·55.
8	20 16 33·76	125 29 15·3	Stone 10897.
9	20 37 7·92	122 19 49·7	Stone 11038.
10	20 38 32·01	120 52 57·7	Stone 11047.
11	20 43 45·60	119 14 31·4	Wash. Mural. Cir. Zone 132·73.
12	20 43 22·43	117 46 53·3	Stone 11075.
13	20 44 51·56	117 39 41·6	Stone 11088.
14	20 46 19·98	117 35 16·9	Cordoba Zone 10·104.
15	20 42 38·59	116 11 38·1	Stone 11072.
16	20 47 26·40	114 42 10·5	Stone 11116.
17	20 48 44·65	114 39 33·9	Cordoba Zone 32·36.
18	20 50 29·26	114 37 25·9	Arg.-Oeltzen 20973.
19	20 58 1·80	110 17 50·1	Stone 11187.
20	21 11 40·39	108 27 13·5	Greenw. 7 Yr. Cat. 1864, 2411.
21	21 9 32·78	105 38 11·1	Stone 11276.
22	21 15 19·01	105 37 48·1	Arg.-Oeltzen 21323.
23	21 17 13·27	103 59 31·7	$Lamont_5$ 3612.
24	21 21 15·73	104 4 22·6	Schjellerup 8679–80.
25	21 20 20·06	102 34 17·1	$Lamont_5$ 3630.
26	21 27 35·35	100 9 20·6	$Lamont_5$ 3676.
27	21 25 35·31	100 13 57·3	$Lamont_5$ 3666.
28	21 40 32·02	94 38 39·6	$Lamont_3$ 4381.
29	21 44 29·44	91 7 36·8	Glasgow, 5594.
30	21 52 9·17	89 55 58·3	Glasgow, 5639.
31	21 55 21·10	89 55 58·9	Glasgow, 5660.
32	22 3 27·96	87 48 50·1	Glasgow, 5705.
33	22 3 13·18	86 18 39·6	Glasgow, 5703.
34	22 4 20·30	86 26 49·9	Lalande 43221.
35	22 0 1·80	85 29 20·7	Glasgow, 5683.
36	22 0 55·08	85 21 1·1	Schjellerup 9018.

Private Observatory, Windsor, N. S. Wales:
1888, *April* 12.

Note on Comet a 1888 (*Sawerthal*). By L. Becker, Ph.D.

(*Communicated by Dr. Copeland.*)

Along with micrometrical observations of Comet *Sawerthal* with the 15-inch equatorial I have made the following notes on its physical appearance. On May 10 the brightness of the comet was compared in an illuminated field with $*9^{\cdot}4$ mag. DM. $+31^{\circ}$, 4984 and $*8^{\cdot}8$ mag. DM. $+31^{\circ}$, 4982, and found to be of $9^{\cdot}5$ mag. It was an easy object for micrometrical measurement. On May $17^{\cdot}6$ the comet appeared in feeble reddish field illumination like a bright, pretty large nebula, hardly brighter in the middle. The north preceding tail was traced for about a minute of arc in rather strong twilight.

On May $21^{\cdot}5$ the remarkable change in the appearance of the comet was first noticed. The nucleus was a well-defined object of a few seconds diameter, from which the matter of the comet appeared to flow out towards the north and south preceding sides, falling over in parabolic curves equally to the north and south. The coma was bounded on the preceding side by two curves of less curvature, extending from the nucleus to the north and south. Both parts of the coma appeared of the same size and their light of equal intensity. There was no trace of the tail on the preceding side seen on May 17. A tangent to the following outline of both parts of the coma was found to be in position angle $0^{\circ}{\cdot}8$. The distance from the north to the south end of the coma was measured $= 57''{\cdot}0$ and $59''{\cdot}5$, both wires of the micrometer being moved in order to obtain unbiassed measures free from zero error. In bright field illumination the *nucleus* was estimated $0^{\cdot}1$ mag. fainter than $*9^{\cdot}0$ mag., DM. 36°, 14, or $= 9^{\cdot}1$ mag.

On May $23^{\cdot}6$ the position-angle of the tangent to the following boundary of the coma was again measured $= 5^{\circ}{\cdot}8$, $5^{\circ}{\cdot}2$, $4^{\circ}{\cdot}9$. The distance of the nucleus from this tangent was measured twice, both wires being altered; it was found $= 16''{\cdot}3$ and $16''{\cdot}5$. In bright field illumination the nucleus appeared $0^{\cdot}3$ to $0^{\cdot}5$ mag. fainter than $*8^{\cdot}7$ mag. DM. $+36^{\circ}$, 25, therefore *nucleus* $= 9^{\cdot}1$. Compared with May 21 the coma did not seem to have changed in form but was not so well defined, perhaps on account of the bad state of the atmosphere.

On March 24 it cleared up about 14^{h}, but owing to the increasing twilight* only a micrometrical connection with a neighbouring star could be secured. The *nucleus* was larger than previously, and appeared decidedly brighter that $*9^{\cdot}2$ mag. DM. 37°, 39. Since then the sky has been overcast. It may

* With regard to the brightness of the summer twilight, it may be mentioned that in the latitude of Dun Echt ($+57^{\circ}$ 10′) a short-sighted person can read the preface to the *Nautical Almanac* by the light of the northern sky at midnight on June 21.

perhaps be well to repeat that all the estimates of brightness have been made in an illuminated field.

Lord Crawford's Observatory, Dun Echt:
1888, *June* 4.

The sketch represents the comet as seen with a power of 240 about $13^h\ 30^m$ G.M.T. in twilight without artificial illumination of the field. For the sake of comparison, Prof. A. Hall's drawing of Encke's comet made at Washington in 1871 is reproduced. (Note added July 16, 1888.)

Note on the Glasgow Star Catalogue.
By Professor R. Grant, F.R.S.

It is now five years since the Glasgow Star Catalogue was published, and it is gratifying to me to know that since its first appearance it has been largely used by astronomers in connection with extra-meridional observations of the minor planets and of comets. This circumstance has encouraged me in an endeavour which I formed, shortly after the publication of the Catalogue, to increase its usefulness still further by a reobservation of the stars in the Catalogue, the places of which, when compared with Bessel's places, exhibited larger discordances than can be accounted for by the ordinary errors of observation. The results thus obtained I contemplated incorporating with the earlier results, either in the form of a Supplementary Catalogue or a new edition of the Catalogue itself, unaccompanied, however, by the annual results of the observations, which constituted so large a part of the work published in 1883. The latter is the form which I have decided upon adopting, and the work of the Observatory is now being directed to a scrutiny of the Catalogue and the preparation of the new star places. The auxiliary computations of precession and secular variation are also receiving due attention. The precessions were computed in duplicate and compared, but the secular variations were not computed in duplicate, and errata occur in them which have been pointed out to me by Mr. J. Plummer and others. All the auxiliary computations of the Catalogue are now undergoing a careful revision at the Observatory. My best thanks are due to those astronomers who have kindly made known to me such errata as came

under their notice in the course of their astronomical researches. According to present arrangement the Catalogue, thus revised and strengthened by new observations, will be ready for printing about the close of next year, and will be in the hands of astronomers in the following summer.

The Observatory, Glasgow:
1888, *May* 30.

Errata in Monthly Notices, Vol. XLVIII.

Page 341, May 10—*dele* Apparent R.A. and Apparent N.P.D. of Comet.
Page 342, bottom line—*for* Lalande 46809 *read* Anonymous. *Dele* R.A., N.P.D., and Authority for this star.

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Page 550, June 19—the G.M.T. should be $11^h\,23^m\,55^s$ *instead of* $11^h\,53^m\,55^s$.